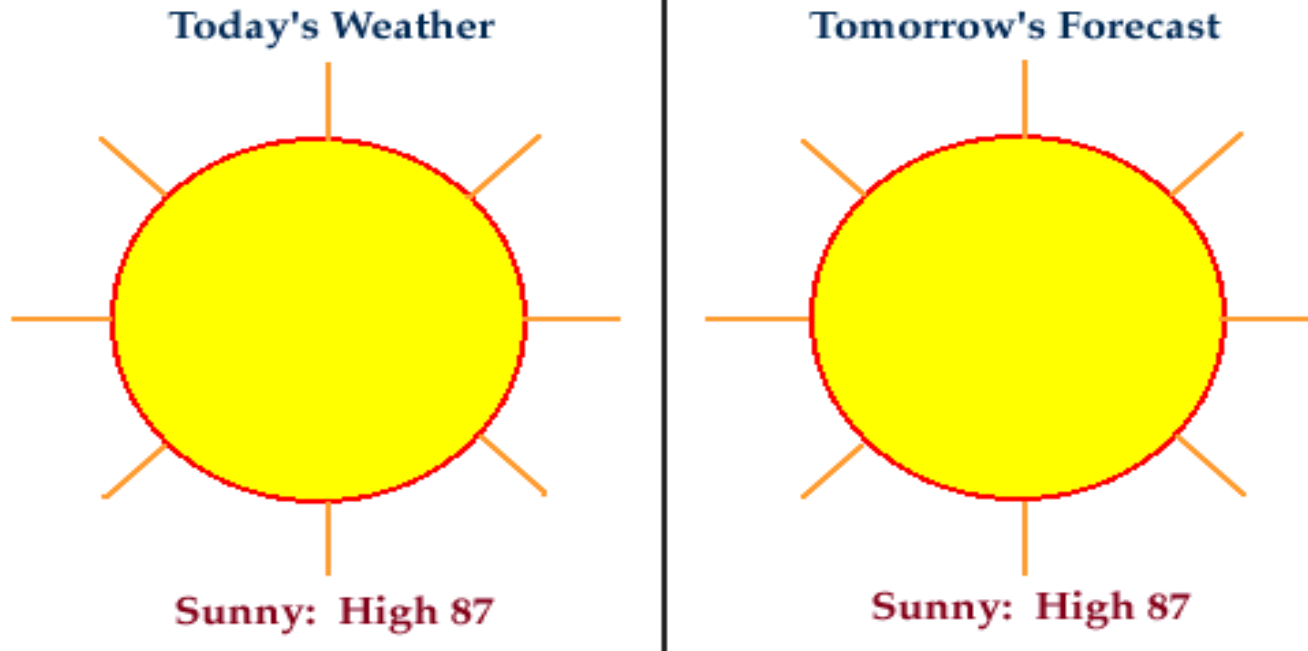


Persistence Method today equals tomorrow

There are several different methods that can be used to create a forecast. The method a forecaster chooses depends upon the experience of the forecaster, the amount of information available to the forecaster, the level of difficulty that the forecast situation presents, and in the forecast



The first of these methods is the Persistence Method; the simplest way of producing a forecast. The persistence method assumes that the conditions at the time of the forecast will not change. For example, if it is sunny and 87 degrees today, the persistence method predicts that it will be sunny and 87 degrees tomorrow. If two inches

The persistence method works well when weather patterns change very little and features on the weather maps move very slowly. It also works well in places like southern California, where summertime weather conditions vary little from day to day. However, if weather conditions change significantly from day to day, the persistence method usually breaks down and is not the best forecasting method to use.

It may also appear that the persistence method would work only for shorter-term forecasts (e.g. a forecast for a day or two), but actually one of the most useful roles of the persistence forecast is predicting long range weather conditions or making climate forecasts. For example, it is often the case that one hot and dry month will be followed by another hot and dry month. So, making persistence forecasts for monthly and seasonal weather conditions can have some skill. Some of the other forecasting methods, such as

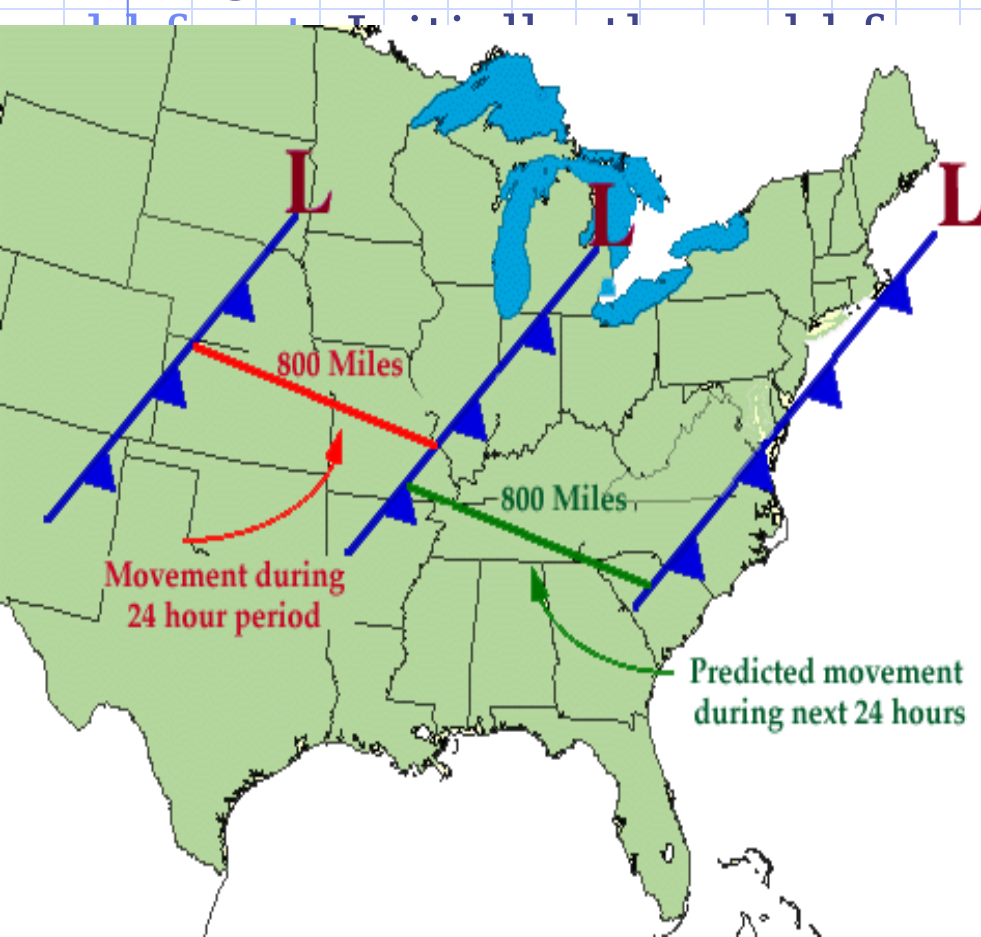
Trends Method using

mathematics

The trends method involves determining the speed and direction of movement for fronts, high and low pressure centers, and areas of clouds and precipitation. Using this information, the forecaster can predict where he or she expects those features to be at some future time. For example, if a storm system is 1000 miles west of your location and moving to the east at 250 miles per day, using the trends method you would predict it to arrive in your area in 4 days. **Mathematics**

$$(1000 \text{ miles} / 250 \text{ miles per day} \\ = 4 \text{ days})$$

Using the trends method to forecast only a few hours into the future is known as "Nowcasting" and this method is frequently used to forecast precipitation. For example, if a line of thunderstorms is located 60 miles to your northwest and moving southeast at 30 miles per hour, you would predict the storms to arrive in your area in 2 hours. Below is an example of using the trends method to forecast the movement of a



low-pressure system that has moved 800 miles during the last 24 hours and is now moving towards the Great Lakes.

Using the trends method, you would predict this weather system to move another 800 miles in the next 24 hours, reaching the East Coast of the United States. The trends method works well when systems continue to move at the same speed in the same direction for a long period of time. If they slow down, speed up, change intensity, or change

climatology, analogue and numerical
weather prediction

Climatology:

The Climatology Method is another simple way of producing a forecast. This method involves averaging weather statistics accumulated over many years to make the forecast. For example, if you were using the climatology method to predict the weather for New York City on July 4th, you would go through all the weather data that has been recorded for every July 4th and take an average. If you were making a forecast for temperature and precipitation, then you would use this recorded weather data to compute the averages for temperature and precipitation. If these averages were 87 degrees with 0.18 inches of rain, then the weather forecast for New York City on July 4th, using the climatology method, would call for a high temperature of 87 degrees with 0.18 inches of rain. The climatology method only works well when the weather pattern is similar to that expected for the chosen time of year. If the pattern is quite

Analog Method:

The Analog Method is a slightly more complicated method of producing a forecast. It involves examining today's forecast scenario and remembering a day in the past when the weather scenario looked very similar (an analog). The forecaster would predict that the weather in this forecast will behave the same as it did in the past.

For example, suppose today is very warm, but a cold front is approaching your area. You remember similar weather conditions one last week, also a warm day with cold front approaching. You also remember how

heavy thunderstorms developed in the afternoon as the cold front pushed through the area. Therefore, using the analog

method, you would predict that this cold front will also produce thunderstorms in the afternoon.

The analog method is difficult to use because it is virtually impossible to find a perfect analog. Various weather features rarely align themselves in the same locations they were in the previous time. Even small differences between the current time and the analog can lead to very different results.

However, as time passes and more weather data is archived, the chances of finding a "good match" analog for the current

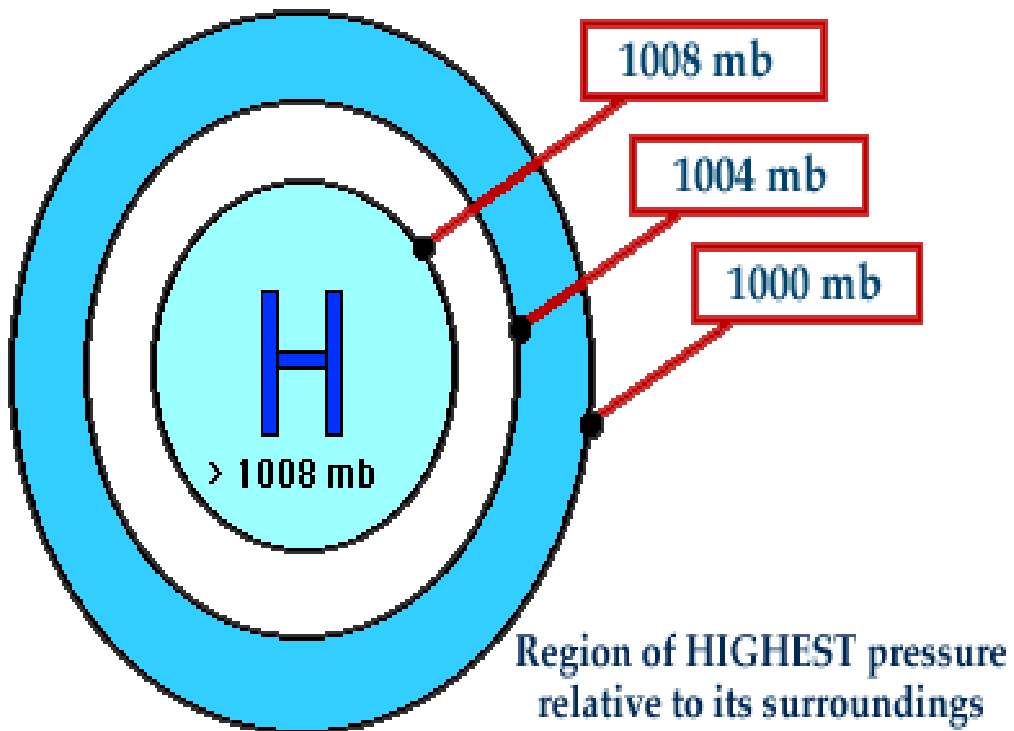
Numerical Weather Prediction:

Numerical Weather Prediction (NWP) uses the power of computers to make a forecast. Complex computer programs, also known as forecast models, run on supercomputers and provide predictions on many atmospheric variables such as temperature, pressure, wind, and rainfall. A forecaster examines how the features predicted by the computer will interact to produce the day's weather. The NWP method is flawed in that the equations used by the models to simulate the atmosphere are not precise. This leads to some error in the predictions. In addition, there are many gaps in the initial data since we do not receive many weather observations from areas in the mountains or over the ocean. If the initial state is not completely known, the computer's prediction of how that initial state will evolve will not be entirely accurate.

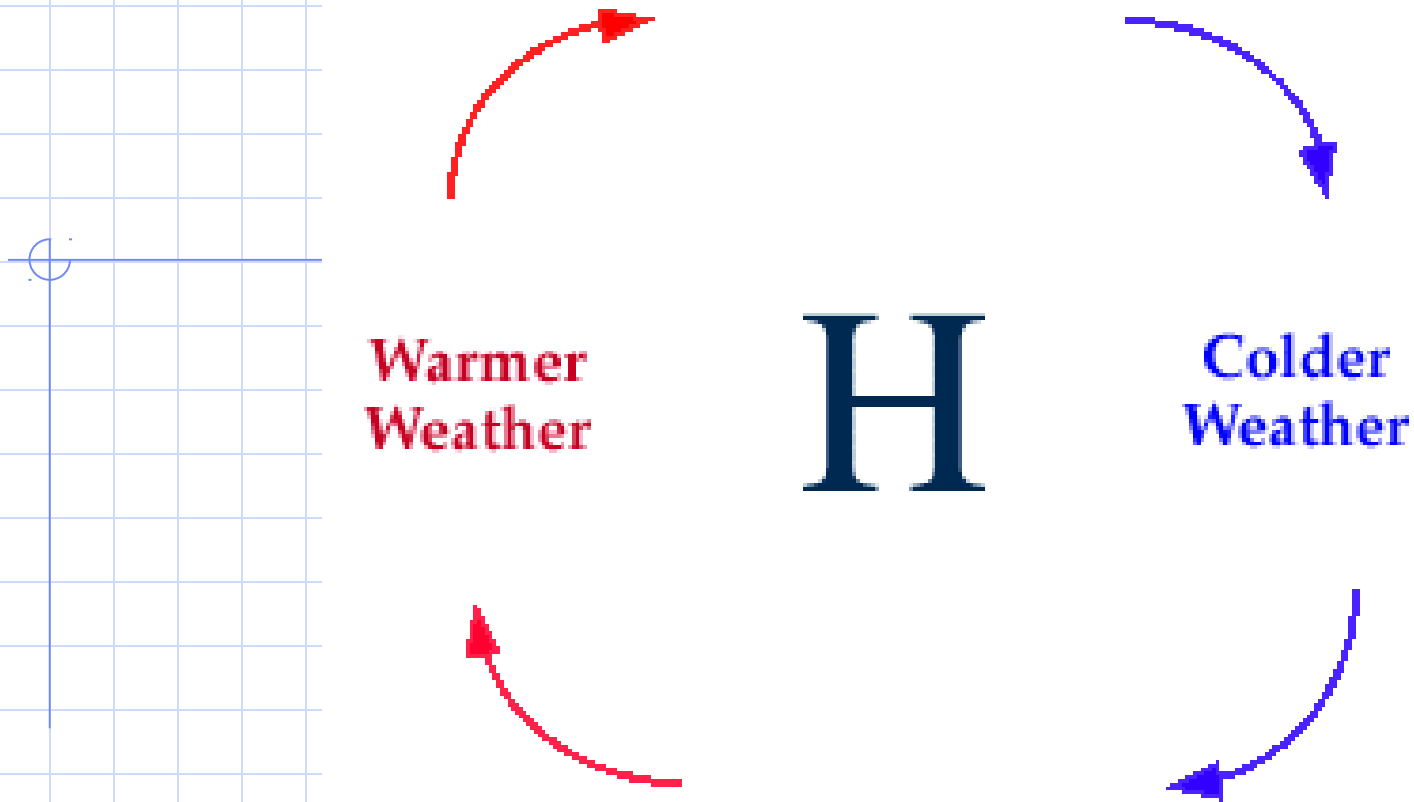
Despite these flaws, the NWP method is probably the best of the five discussed here at forecasting the day-to-day weather changes. Very few people, however, have access to the computer data. In addition, the beginning forecaster does not have the knowledge to interpret the computer forecast, so the simpler forecasting methods, such as the **trends** or analogue

Anticyclones bringing fairer weather

There are several key surface features to consider when making a forecast. We will begin this discussion with the anticyclone, which is a high pressure center where the pressure has been measured to be the highest relative to its surroundings. That means, moving any direction away from the "High" will result in a decrease in pressure. High pressure is the center of anticyclones.



A high pressure center is represented on a weather map by a blue "H" and air diverges outward from a surface high. With air moving away from this region, air must sink from above to replace it. This sinking motion leads to generally fair skies and

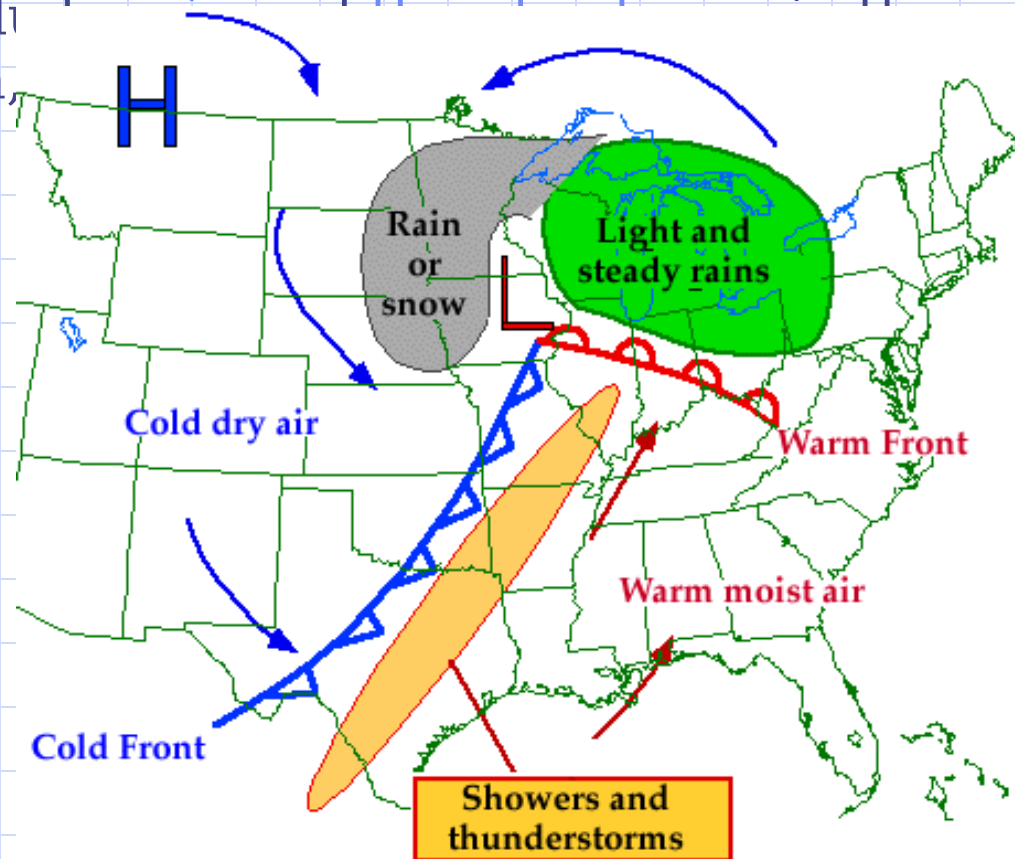


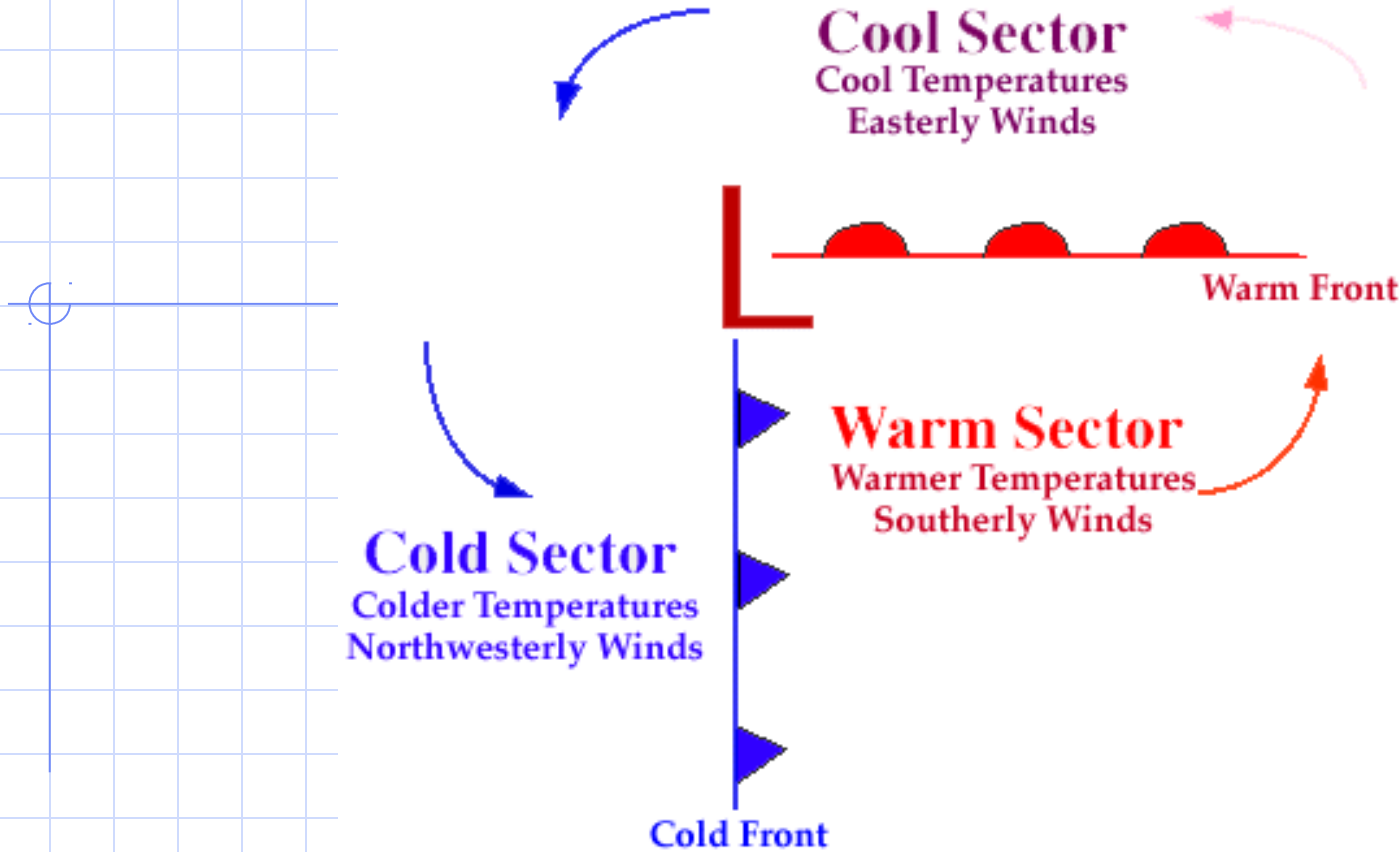
Winds flow clockwise around a **high pressure center** in the northern hemisphere (above). Temperatures are dependent upon the location relative to the high. Northerly winds associated with an approaching high are likely to result in colder temperatures while southerly winds found on the backside of a high, or once a high has

Cyclones bringing clouds and precipitation

A **cyclone** is an area of low pressure around which the winds flow counterclockwise in the northern hemisphere. Since a cyclone is also known as a **low pressure center**, moving in any horizontal direction away from the "Low" will result in increasing pressure. Air converges into a low pressure center which causes air to rise. The **rising motion** may produce clouds and precipitation. Different precipitation types include summer and fall seasons, to rain, during the winter.

A low is represented on a weather map by a red "L". As a **cyclone** approaches, the likelihood of clouds and precipitation increases.





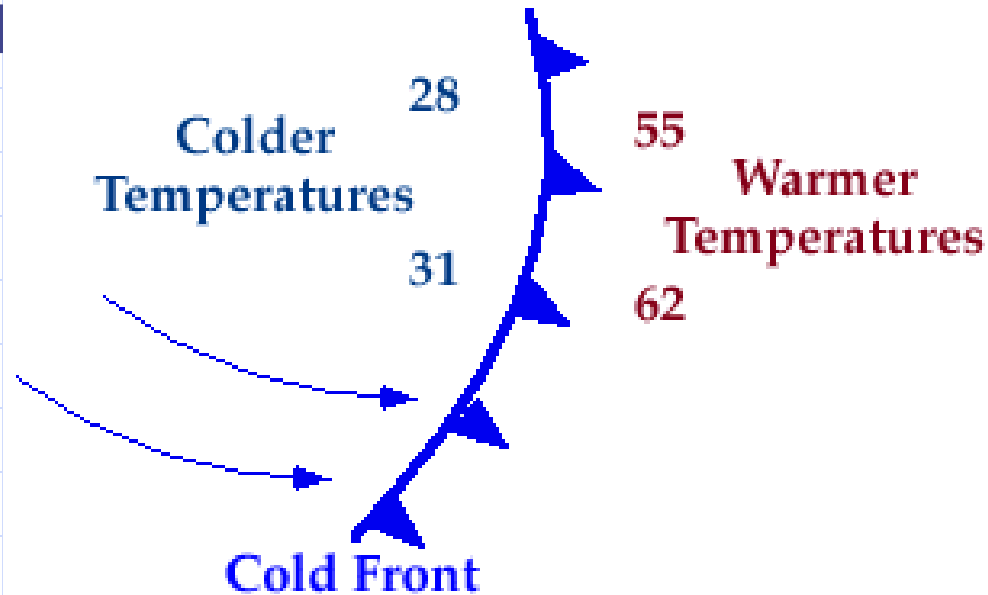
Winds flow counterclockwise around a low pressure center in the northern hemisphere and temperatures are dependent upon the location relative to the low. Southerly winds associated with an approaching cyclone are likely to result in warmer temperatures while northerly winds

Cold Fronts

colder temperatures and possibly

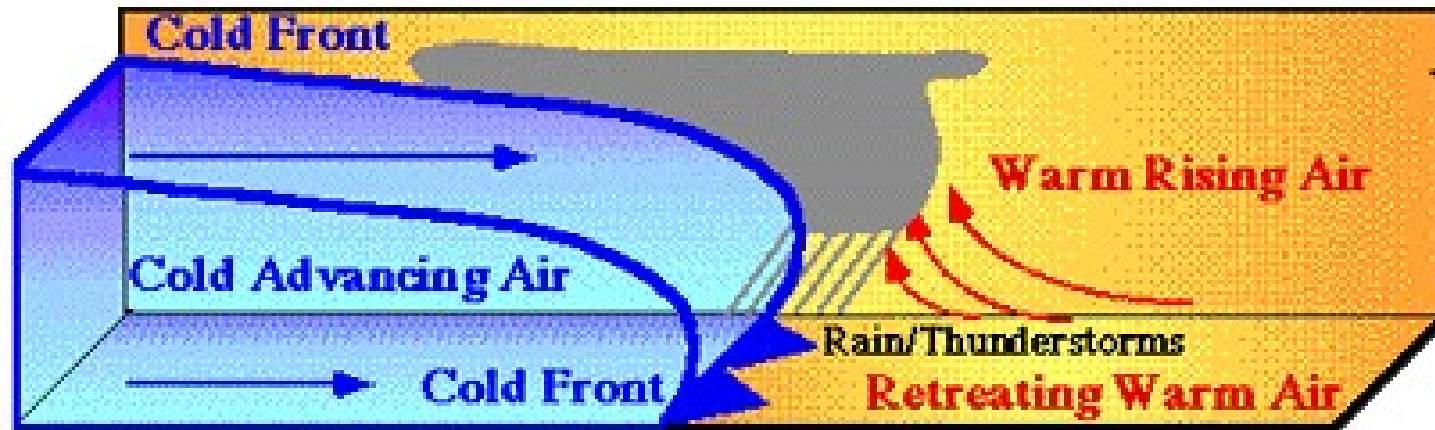
precipitation

A **cold front** is defined as the transition zone where a cold air mass is replacing a warmer air mass. In the example below, temperatures ahead of the cold front are 55 and 62 degrees while behind the front, the temperatures are lower, 31 and



The air mass behind a **cold front** is likely to be cooler and drier than the one before the front. If a cold front is approaching, precipitation is possible just before and while the front passes. Behind the front, expect clearing

The picture below is a vertical cross-section depicting the development of precipitation ahead of and along cold front. The blue mass represents the colder air behind the cold front (solid blue line) and the yellow areas indicate the warm air.

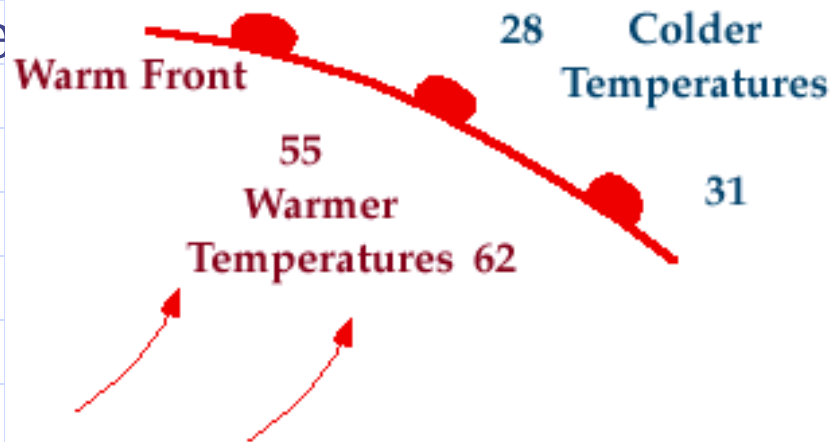


As the cold air mass propagates, it lifts the warmer less dense air ahead of it (red arrows). The air cools as it rises and the moisture condenses to produce clouds and precipitation ahead of and along the cold front. In contrast to lifting along a warm front, upward motions along a cold front are typically more vigorous, producing deeper clouds and more intense bands of showers and thunderstorms. However, these bands are

Warm Fronts

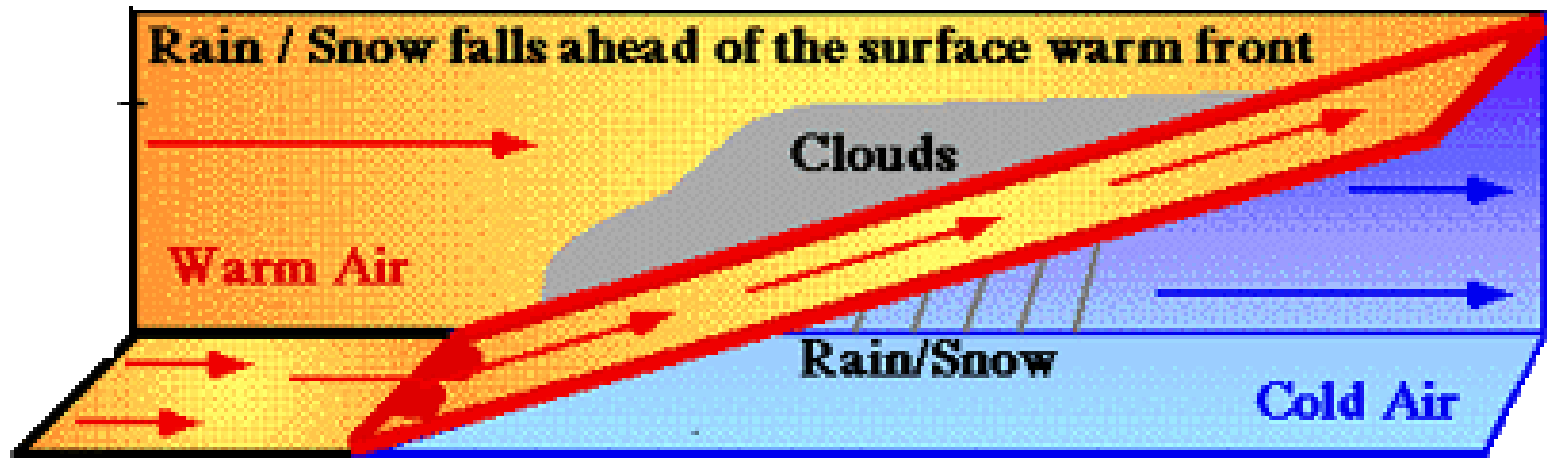
warm and more moist
conditions

A **warm front** is the transition zone where a warm air mass is replacing a cold air mass. The air behind a warm front is generally warmer and more moist than the air ahead of it. A likely scenario has been depicted below, where temperatures ahead of the front are in the 20's and 30's while behind the front are in the 50's and 60's.



The air mass behind a **warm front** is likely to be warmer and more moist than the one before the front. If a warm front is approaching, light rain or light winter precipitation is possible before and as the front passes. Behind the front, expect clearing skies, warmer

The figure below is a vertical cross section depicting the development of precipitation ahead of and along a warm front. The region shaded in blue represents the colder air mass while the yellow areas indicate the warm moist air mass behind

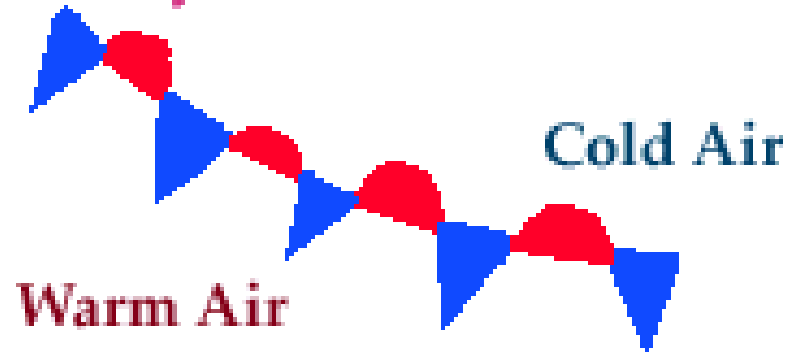


The surface of the warm front extends vertically into the atmosphere, sloping up and over the colder air ahead it. Warm air rides up and over the cold air mass, cooling as it rises, producing clouds and precipitation in advance of the surface warm front. Because the lifting is very gradual and steady, generally wide spread and light-

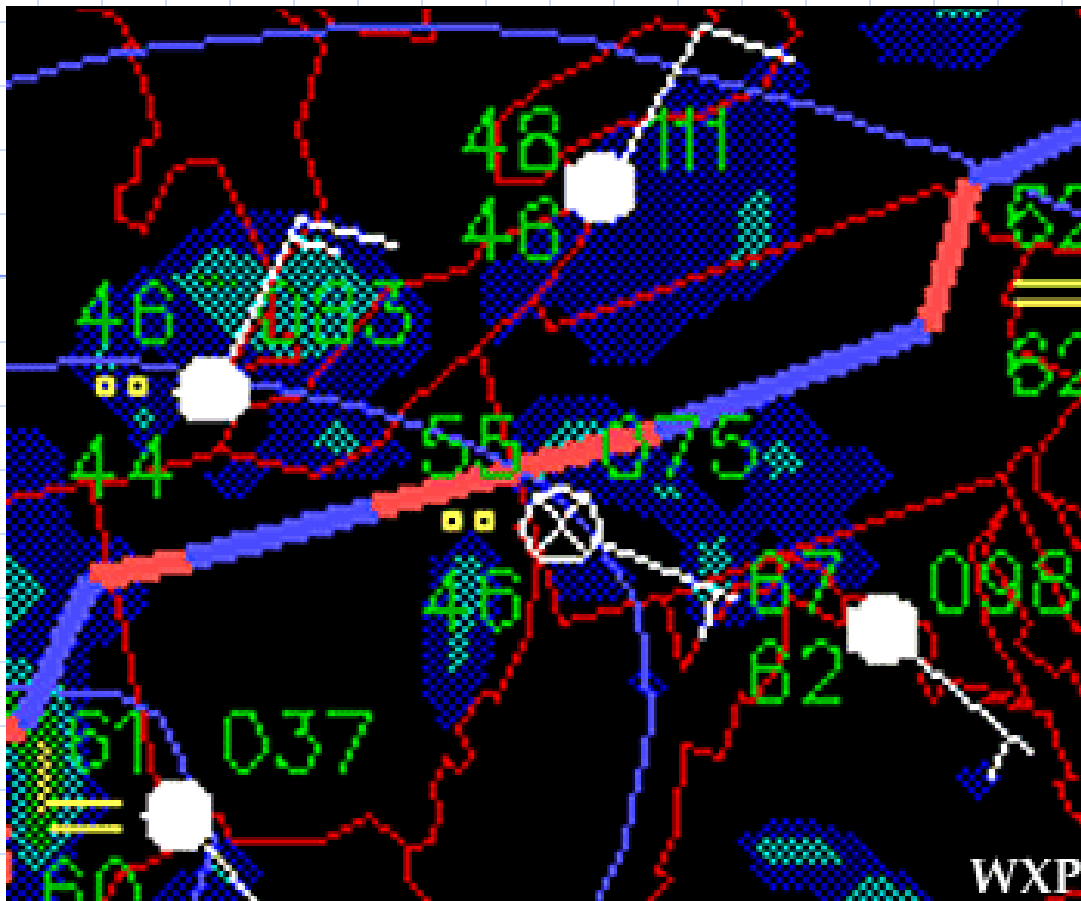
Stationary Fronts runway for cyclones

A stationary front is simply a front that is not moving. It is represented by alternating blue and red lines with blue triangles pointing towards the warmer air and red semicircles pointing towards the colder air.

Stationary Front



Weather conditions greatly depend upon which side of the front a location is positioned. If a stationary front is nearby and a low pressure center is approaching along the front, heavy amounts of precipitation are possible.



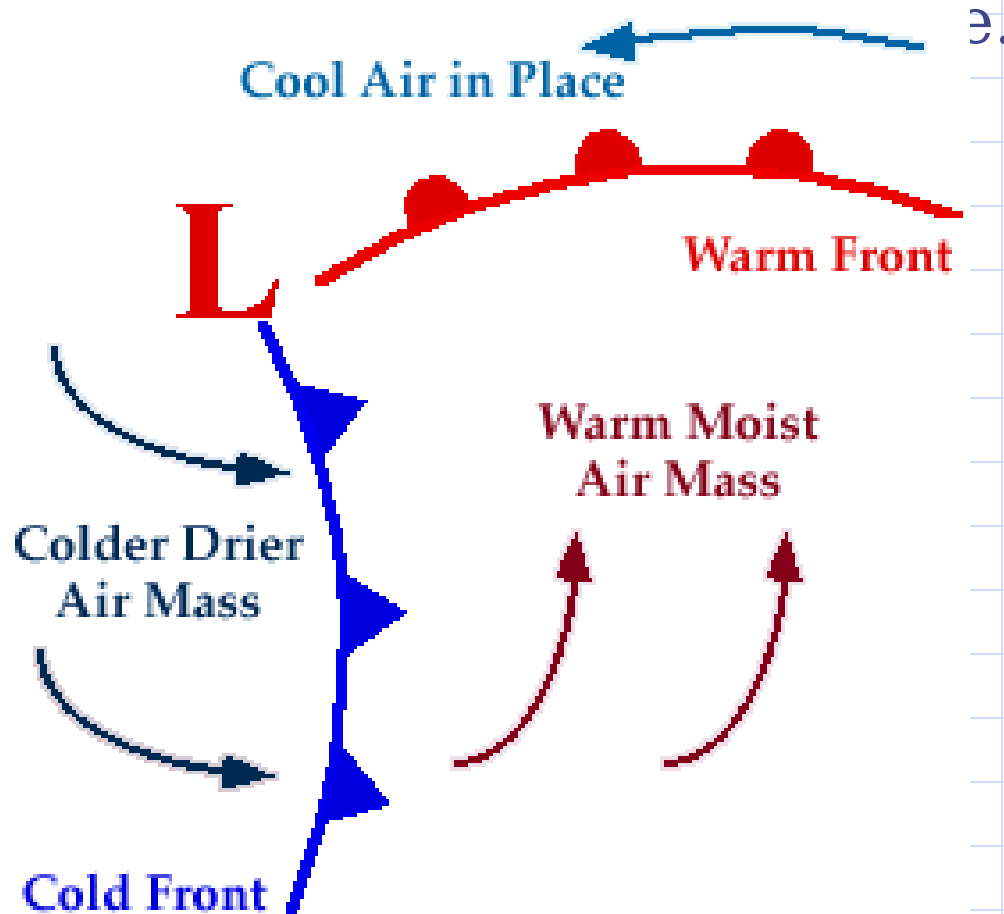
There is usually a noticeable change in temperature and wind shift crossing from one side of a stationary front to the other. Low pressure centers sometimes migrate along stationary fronts, dumping heavy amounts of precipitation in their path. Such a scenario has been depicted above. The alternating red and blue line is the

Occluded Fronts

when a cold front catches a

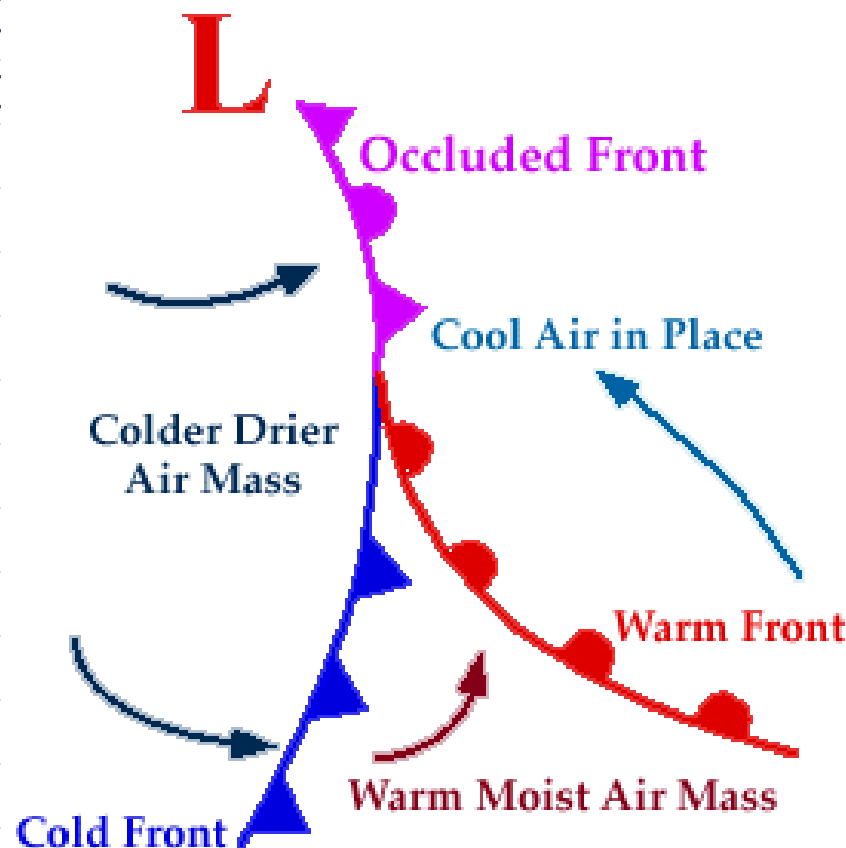
warm front

An occluded front develops when a cold front catches a warm front. For a maturing cyclone, a warm front is progressing northward ahead of the storm center while a cold front is sweeping southeastward. The cool air mass north of the

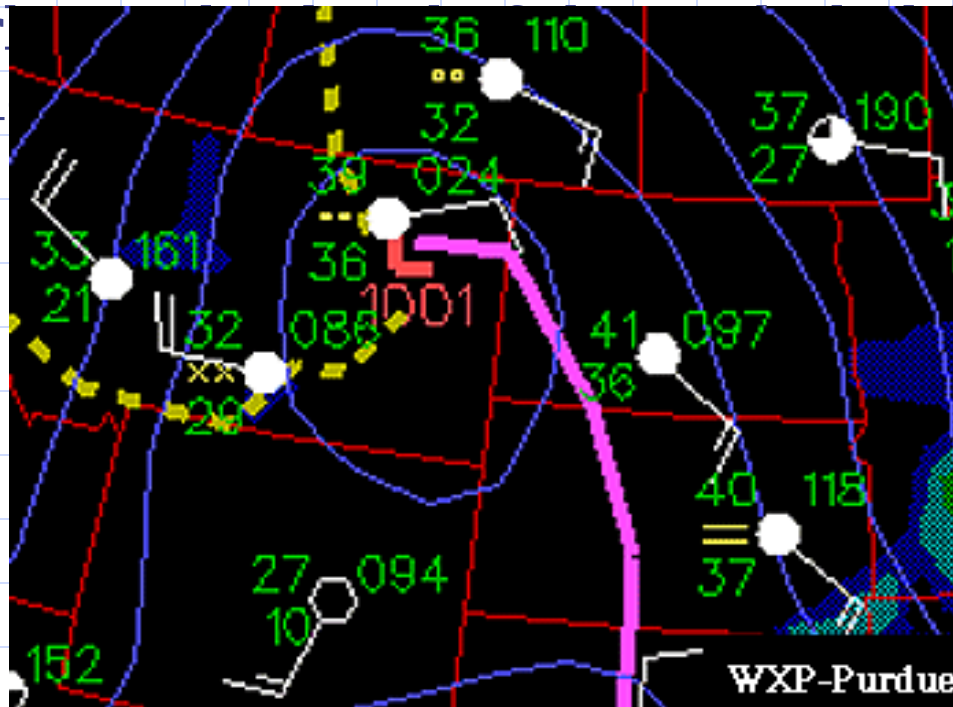


As the storm intensifies, the cold front rotates around the storm and catches the warm front. This forms an occluded front, which is the boundary that separates the new cold air mass (to the west) from the older cool air mass already in place north of the warm front.

Symbolically, an occluded front is represented by a solid line with alternating triangles and circles pointing the direction the front is moving. On weather maps, an occluded front is represented by a solid line with alternating triangles and circles pointing the direction the front is moving.



Ahead of the occluded front, temperatures were reported in the low 40's, while temperatures behind the front were in the 20's and 30's. The air mass behind the front is also drier as shown by the lower dew points. Wind direction reports to the east of the front are from the east or southeast, while winds behind the front are from the west or southwest. Convergence of the easterly and westerly winds results in the formation of rain or snow.



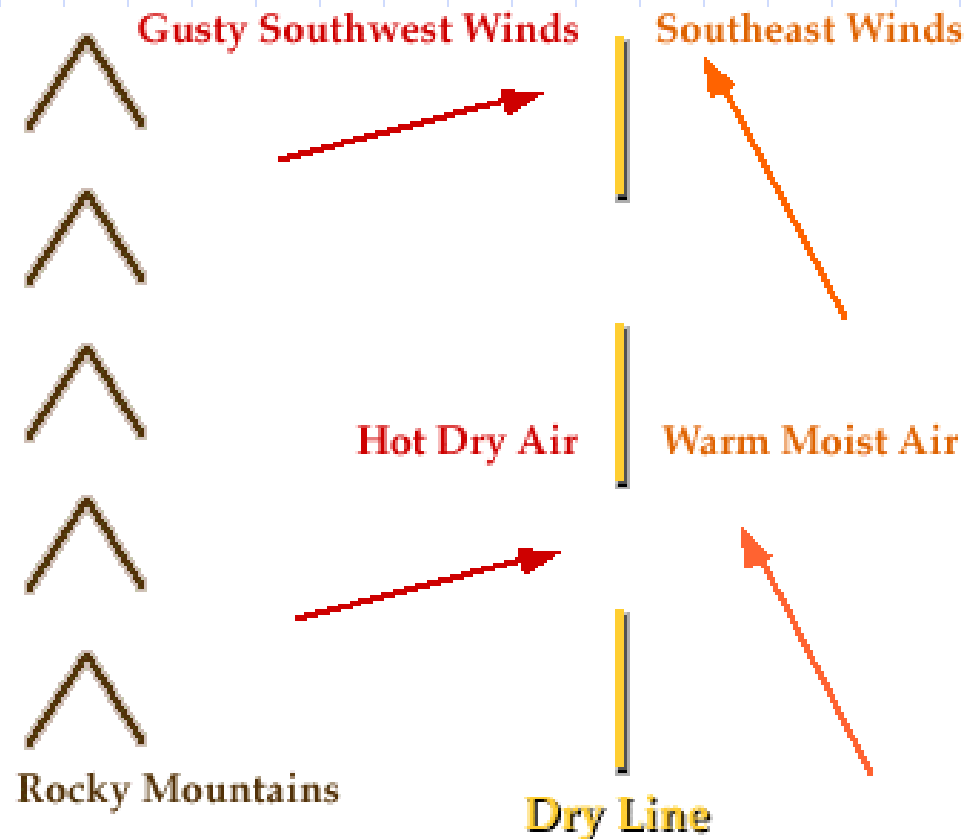
With the passage of an occluded front, weather conditions will likely turn from cool to cold. Winds will swing around from easterly to westerly or southwesterly with rain or snow showers possible, (depending upon how cold the temperatures

Dry Line a moisture boundary

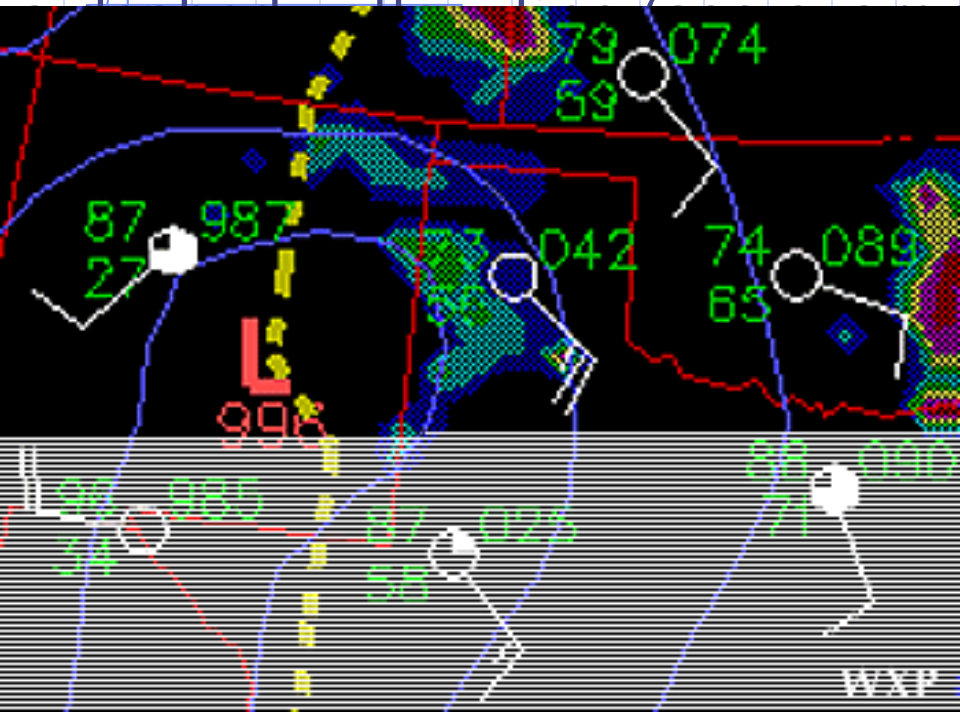
Forecast Tip:

If a dryline is approaching your region, predict that air will be much drier after the boundary moves through. Storms are possible as the dryline approaches. The temperature may rise after the dryline passes through, since dry air heats up more quickly than moist air.

A dryline is a boundary that separates a moist air mass from a dry air mass. A dryline is also called a **Dew Point Front**. Sharp changes in dew point temperature can be found across a dryline (sometimes 9 degrees Celsius per kilometer). Drylines are most commonly found just east of the Rocky Mountains, separating a warm, moist air mass to the east from a hot



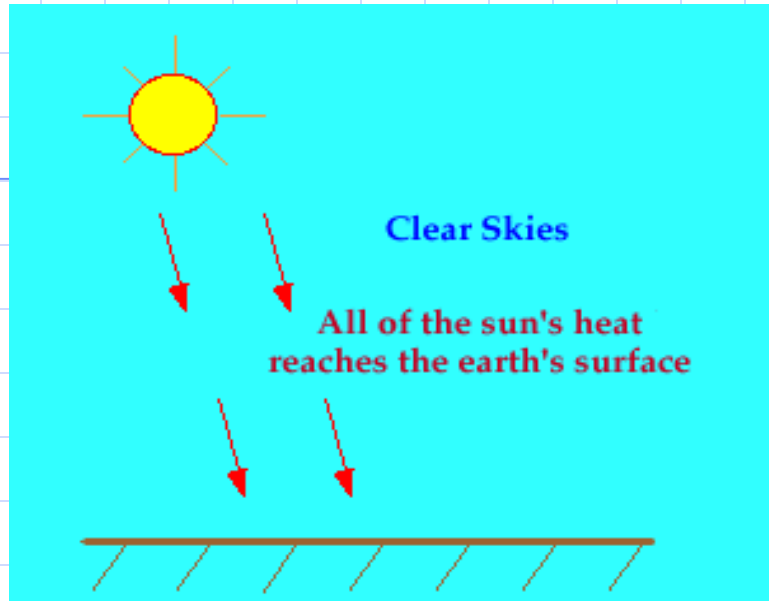
States like Texas, New Mexico, Oklahoma, Kansas, and Nebraska frequently experience drylines in the spring and summer, while east of the Mississippi River, drylines are extremely rare. The dryline is represented on surface maps by (see figure below).



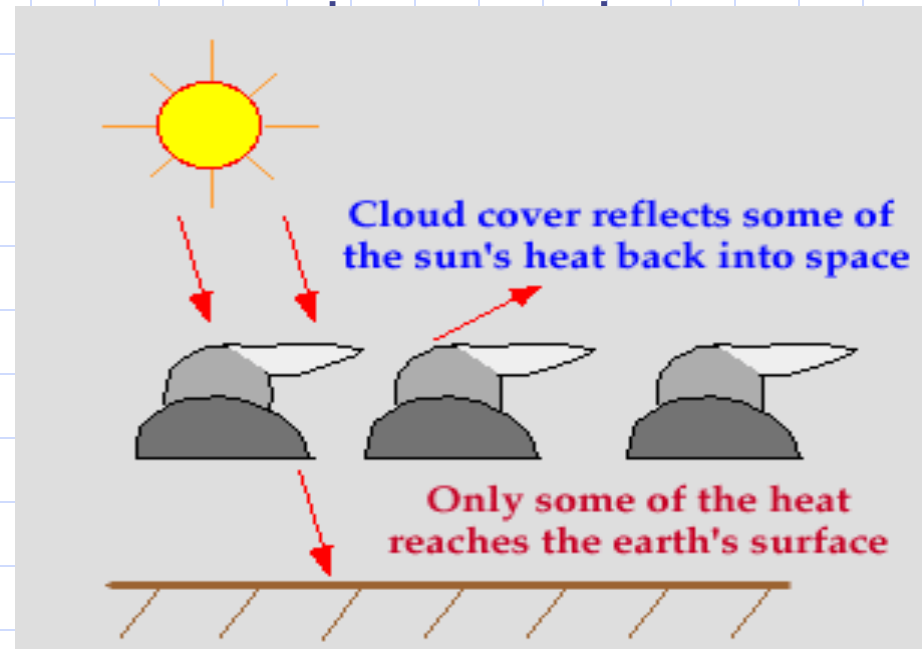
Dew points east of the dryline shown above range from the upper 50's to low 70's, with winds from the southeast. West of the dryline, dew points are much lower, in the 20's and 30's, which is almost 50 degrees less than those found east of the dryline.

Air temperature ahead of the dryline is generally in the 70's and 80's. Behind the dryline, temperatures are hotter, ranging from the mid 80's to mid 90's. The drier air behind the dryline lifts the moist air ahead of it as it advances, which could lead to the development of thunderstorms along and ahead of the dryline in a manner similar

Effects of Cloud Cover on forecasted temperatures



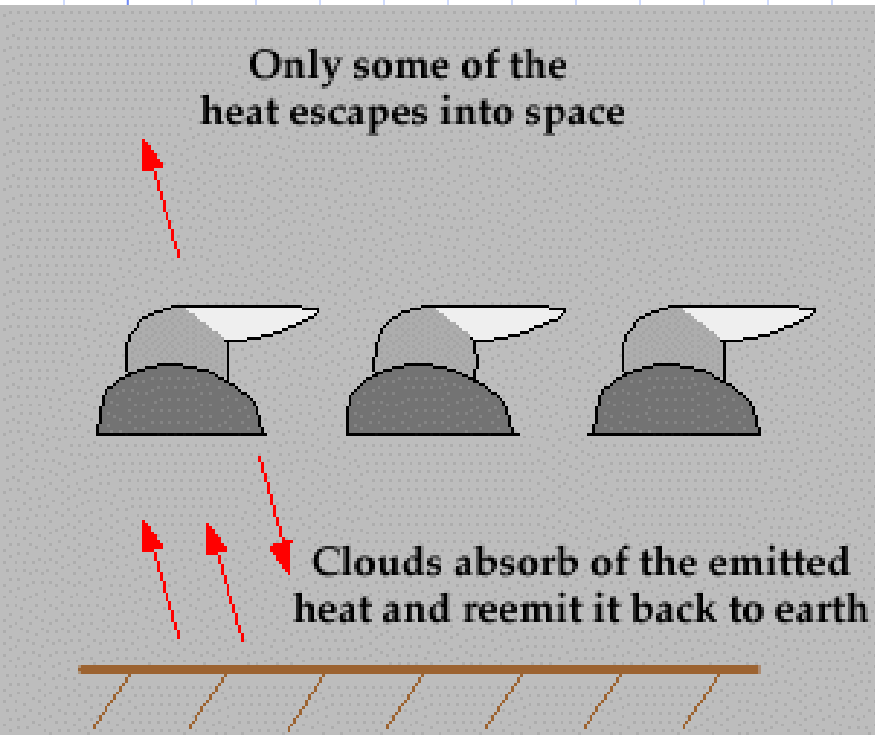
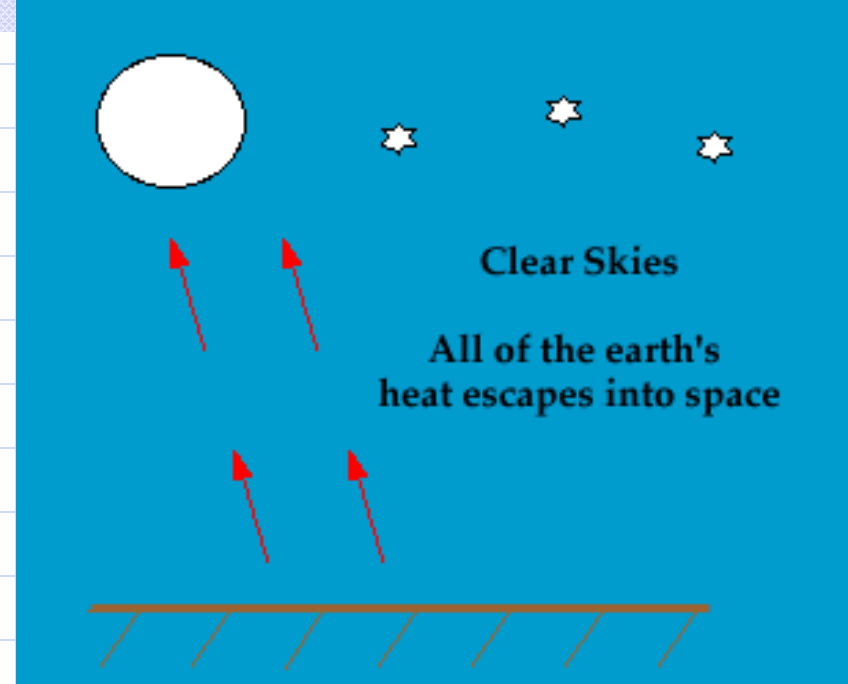
During the day, the earth is heated by the sun. If skies are clear, more heat reaches the earth's surface (as in the diagram below). This leads to



However, if skies are cloudy, some of the sun's rays are reflected off the cloud droplets back into space. Therefore, less of the sun's energy is able to reach the earth's surface, which causes the earth to heat up more slowly. This leads to

Forecast Tip: When forecasting daytime temperatures, if cloudy skies are expected, forecast lower temperatures than you would predict if

At night cloud cover has the opposite effect. If skies are clear, heat emitted from the earth's surface freely escapes into space, resulting in colder temperatures.



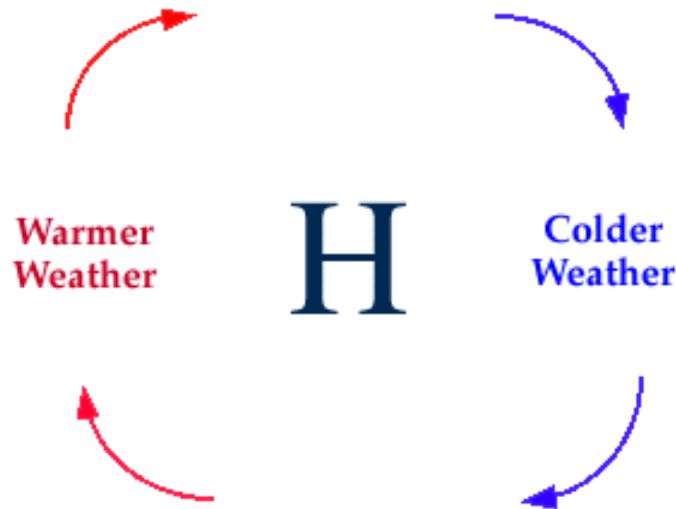
However, if clouds are present, some of the heat emitted from the earth's surface is trapped by the clouds and reemitted back towards the earth. As a result, temperatures decrease more slowly than if the skies were clear.

Forecast Tip:

When forecasting nighttime temperatures, if cloudy skies are expected, forecast warmer temperatures than you would predict if

High and Low Pressure Centers on forecasted temperatures

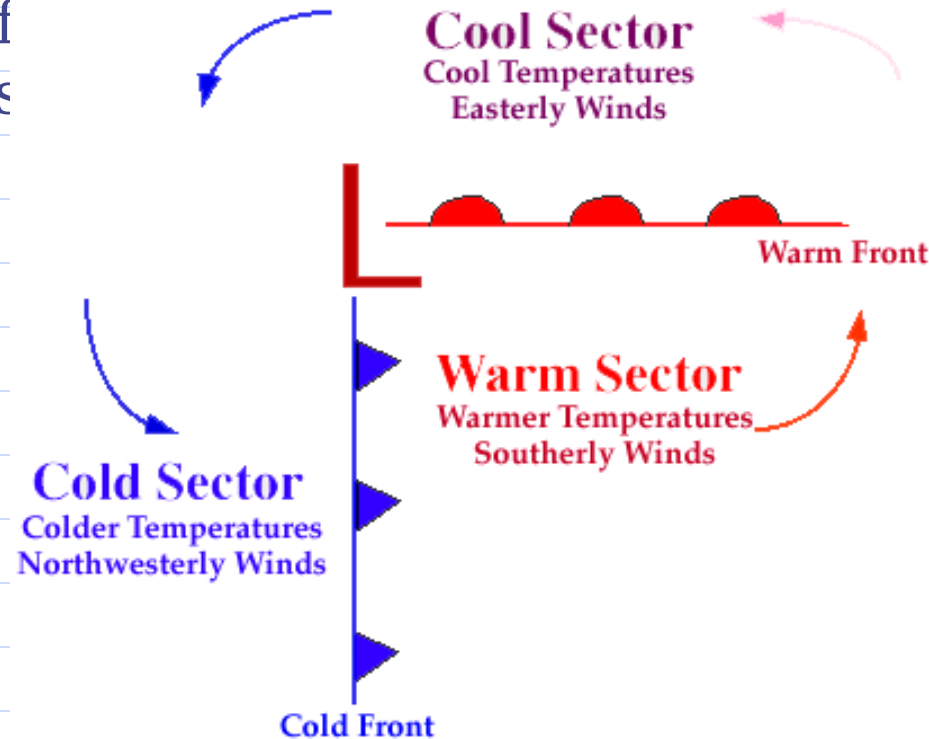
The positions of **high and low pressure centers** can greatly influence a forecast. Fair weather generally accompanies a **high pressure center** and winds flow clockwise around a high. This means that winds on the back (western) side of the high are generally from a southerly direction and typically mean warmer temperatures. On the front (eastern) side of a high, winds are generally from a northerly direction and typically results in colder temperatures.



Forecast Tip:

If a city is expected to be located west of a **high pressure center** then warmer temperatures are likely. However, if the city is expected to be in the northerly winds of a high pressure center, then forecast colder temperatures. Cities under the influence of high pressure

In contrast, clouds and precipitation generally accompany a low pressure center and winds flow counterclockwise around lows. This means that winds on the back (western) side of the low are generally from a northerly direction and typically mean colder temperatures. On the front (eastern) side of this typically res



Forecast Tip:

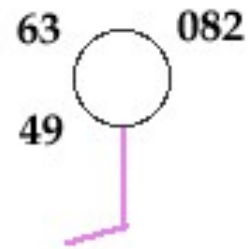
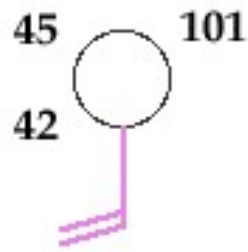
If a city is expected to be located west of a low pressure center then colder temperatures are likely. However, if the city is expected to be in the southerly winds of a high pressure center, then forecast warmer temperatures. Cities under the influence of low pressure

Effects of Temperature Advection on forecasted temperatures

Forecast Tip:

When forecasting temperatures, look at the temperatures upstream from the station for which you making a forecast. If they are warmer, that means warmer air is being transported towards your station and the temperature should rise. Put in another way, if there is **warm advection** occurring at a given station, expect the temperatures to increase. In contrast, if cold advection is occurring at a given station, expect the temperatures to drop.

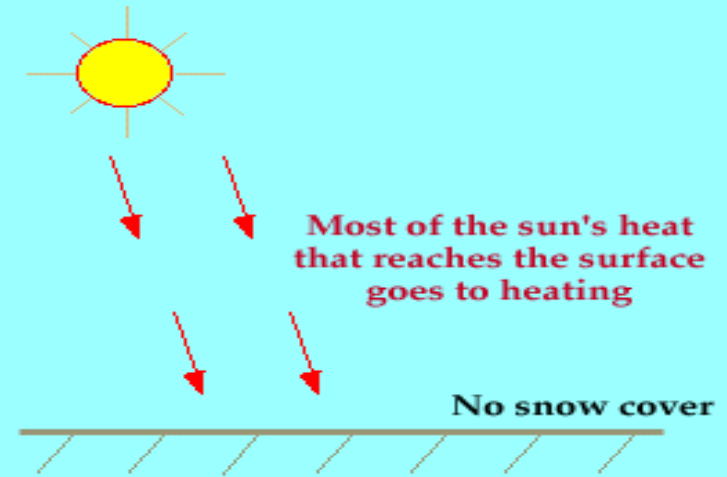
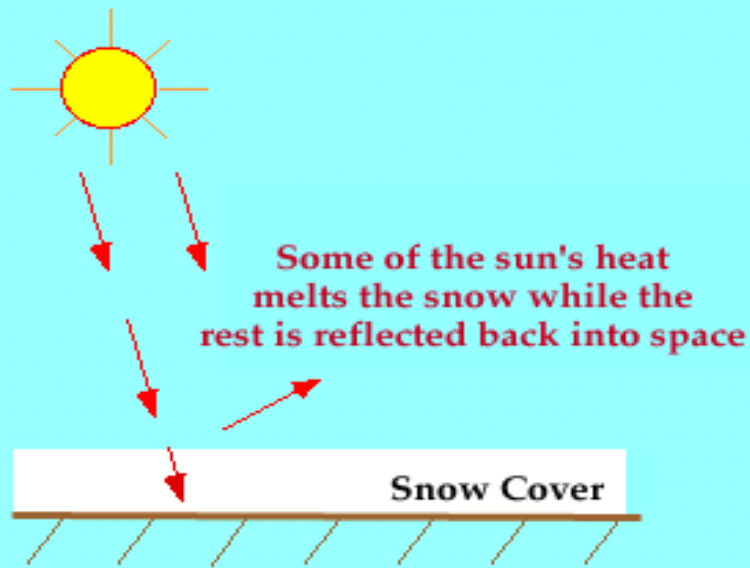
Temperature advection refers to change in temperature caused by movement of air by the wind. Forecasting temperatures using advection involves looking at the wind direction at your forecasting site and the temperatures upstream (in the direction from which the wind is blowing).



For example, consider the two cities below. Assume that a temperature forecast is being made for the northern station, which has a **reported temperature** of 45 degrees. The northern station is cooler than the southern station, but the **wind directions** are the same, out of the south. The wind is, in effect, blowing from the southern station towards the northern one. Over time, the wind will transport the warmer air located at the southern station towards the northern station (into a region of colder air), so expect the temperature at the northern station to rise. This process is called **warm**

Effects of Snow Cover on forecasted temperatures

As the sun's rays hit the surface of the earth, much of it is absorbed by the surface (as in the diagram below). This in turn warms the air near the earth's



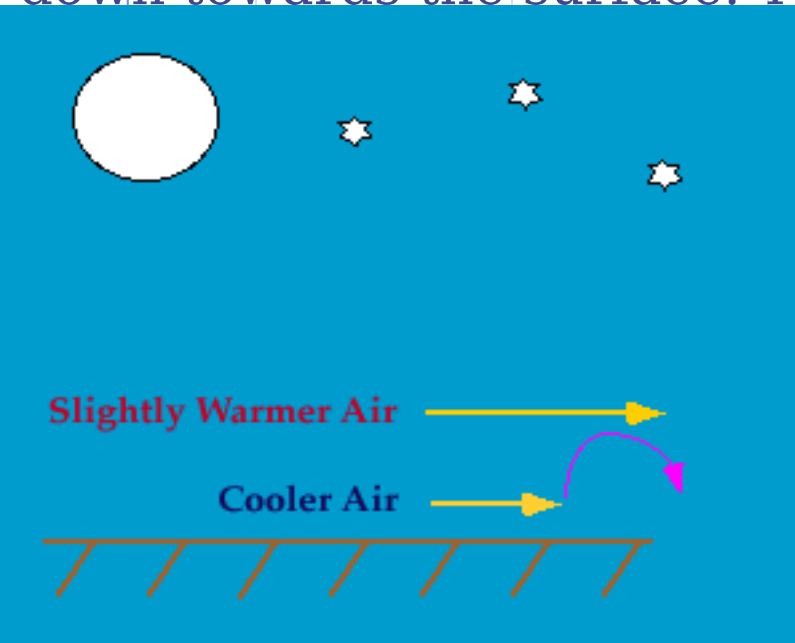
If there is snow on the ground, some of the sun's energy will be reflected away by the snow, and some of it will be used to melt the snow. This means that there is less energy available to heat the earth's surface and consequently, the temperatures rise more slowly than would occur with no snow on the ground.

Forecast Tip:

When snow cover is present, forecast lower daytime temperatures than you would normally predict if there was no snow cover. At night, snow on the ground readily gives off heat. This causes rapid cooling. Forecast the overnight temperature to be lower than you

Effects of Wind on forecasted temperatures

At night, the earth's surface temperatures radiating heat off to space. The strongest cooling takes place right near the surface while temperatures at roughly 3000 feet are actually warmer than those at the surface. On a windy night, some of the warmer air aloft is mixed down towards the surface. This occurs because the winds are faster



To visualize this, place one hand over the other about six inches apart. The bottom hand represents the air near the surface and the top hand represents the warmer wind higher up. Move the bottom hand slowly and the upper hand faster (to indicate the faster winds aloft). The faster air above and slower air below causes the air to overturn or spin (as in the picture below). This overturning motion is how warmer air from above is transported downward on windy nights.

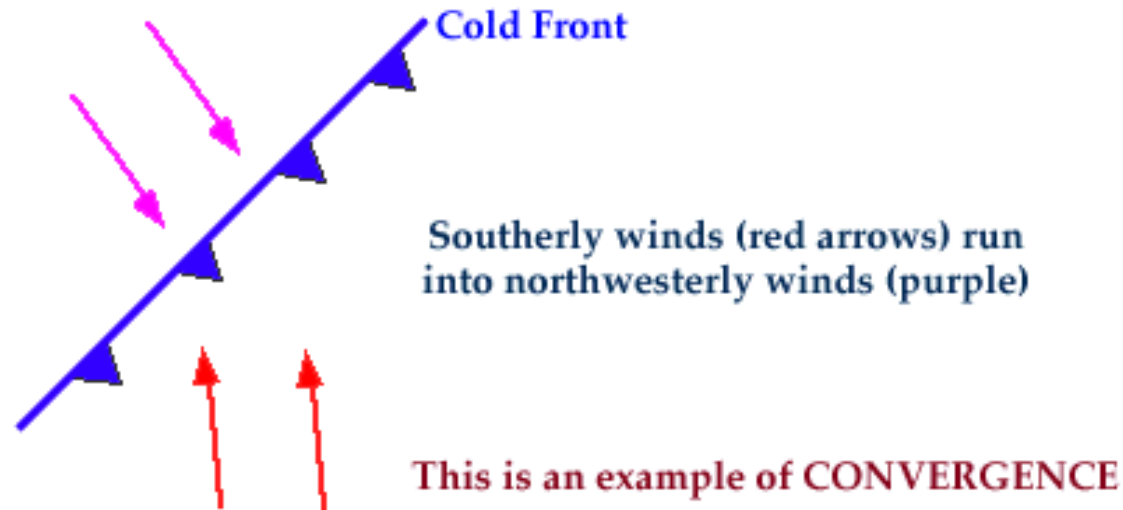
Forecast Tip:

On a calm night, the maximum surface cooling can take place. But on a windy night, some warmer air is mixed downward to the surface, which prevents the temperatures from dropping as quickly as they would on a clear night. Therefore, forecast slightly warmer

Effects of Frontal Lifting on forecasted precipitation

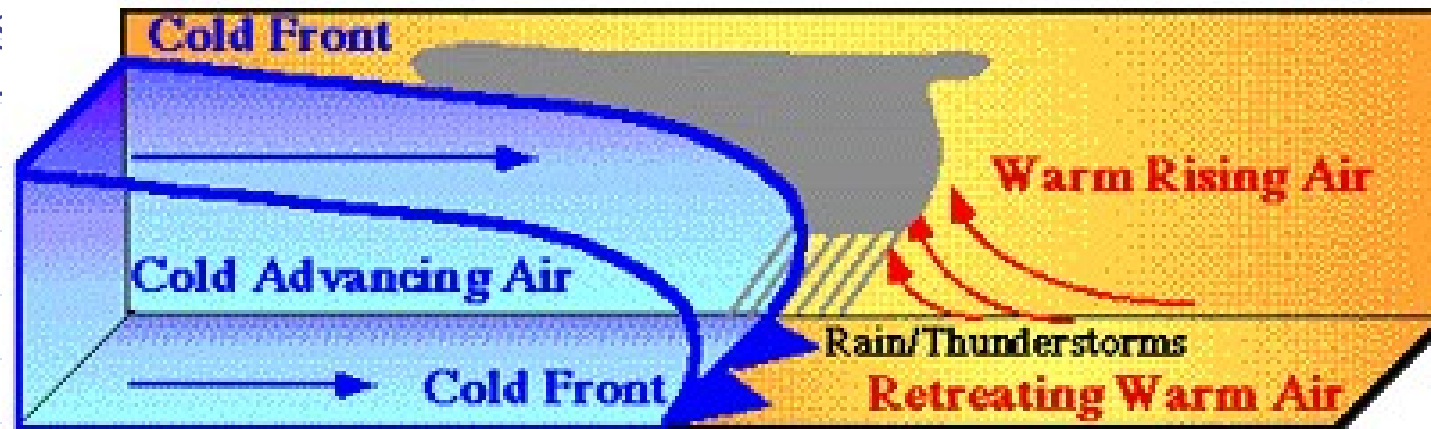
Forecast Tip:

If there is sufficient moisture in the air and a forcing mechanism like a cold front (for example) is approaching the area, then there is an increased probability that precipitation will occur.



Clouds and precipitation are formed by the upward motion of air. Therefore, there must be a mechanism present to lift the air. **Fronts** often serve as such a mechanism. Air on one side of the front typically blows in a different direction from the wind on the other side, causing the air to converge, or pile up right along the frontal surface.

Since this air has to go somewhere, it rises. As air rises, the moisture in the rising air cools, condenses and forms clouds and precipitation. For example, a cold front lifts warm moist air ahead of it as it advances. The rising air cools and the water vapor condenses out to form clouds (diagram).



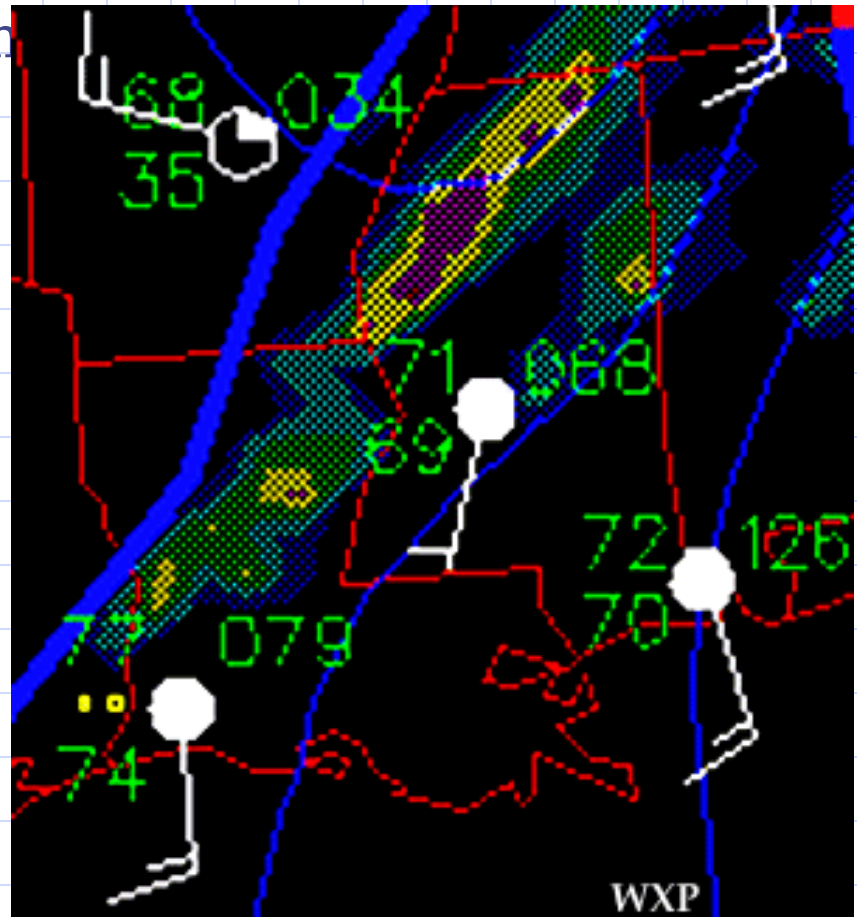
As the cloud droplets grow in size, they begin to fall back to the earth as precipitation. Vigorous upward motions often occur ahead of and along a cold front, resulting in more vertically developed clouds like cumulonimbus clouds, which themselves can produce heavy rains and powerful thunderstorms.

Forecast Tip:

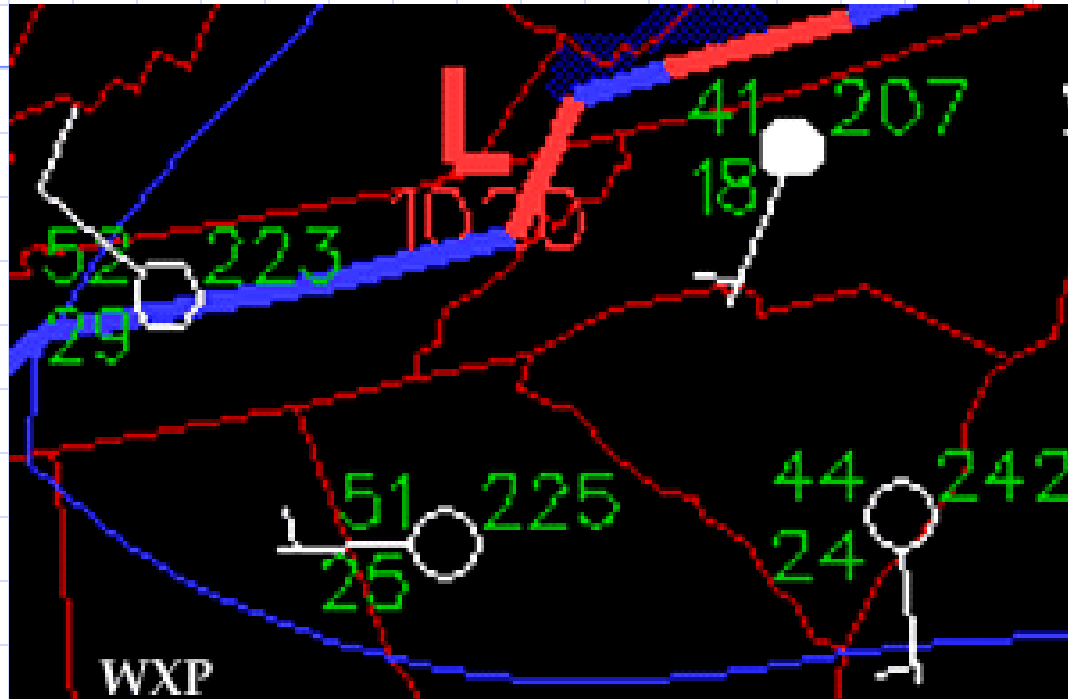
If there is sufficient moisture in the air and a forcing mechanism like a cold front (for example) is approaching the area, then there is an increased probability that precipitation will occur.

Effects of Moisture on forecasted precipitation

Even if there is a mechanism to lift the air, clouds and precipitation may not occur if the low levels of the atmosphere do not contain sufficient moisture. The availability of moisture is revealed on a surface map through the dew point temperatures. If the dew point is close to the corresponding temperature, the precipitation is quite possible. Consider the example below where a cold front was approaching the southeastern United States. The values of the temperatures and dew point temperatures at stations ahead of the front are close together, meaning the air is nearly saturated. Since the dew points are quite high, these factors indicate that there is sufficient moisture for precipitation to develop, and



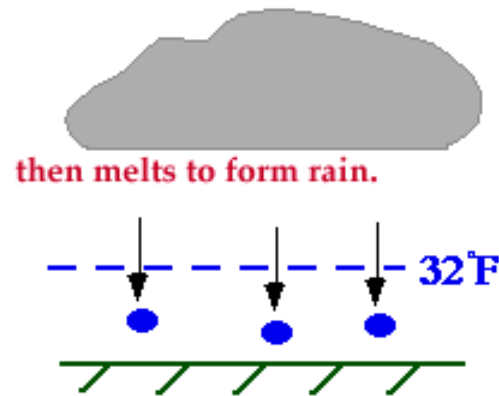
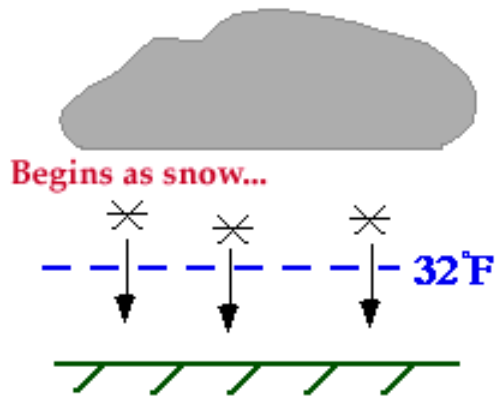
Now consider a different example with a stationary front (depicted on the surface map below).



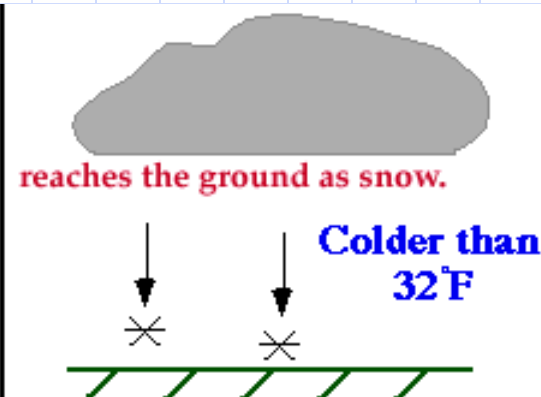
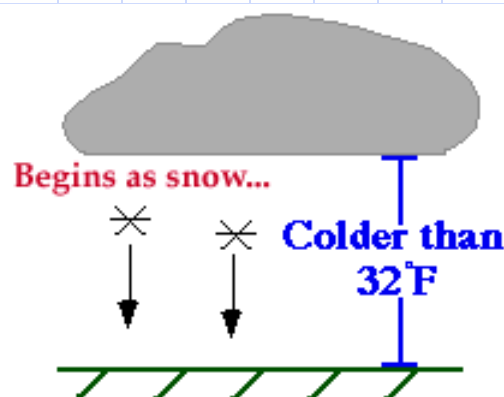
The values of the temperatures and dew points near the front are further apart, meaning the air is quite dry. Therefore, despite the lift provided by the convergence along the front, there is insufficient moisture for

Rain or Snow? dependent upon temperature

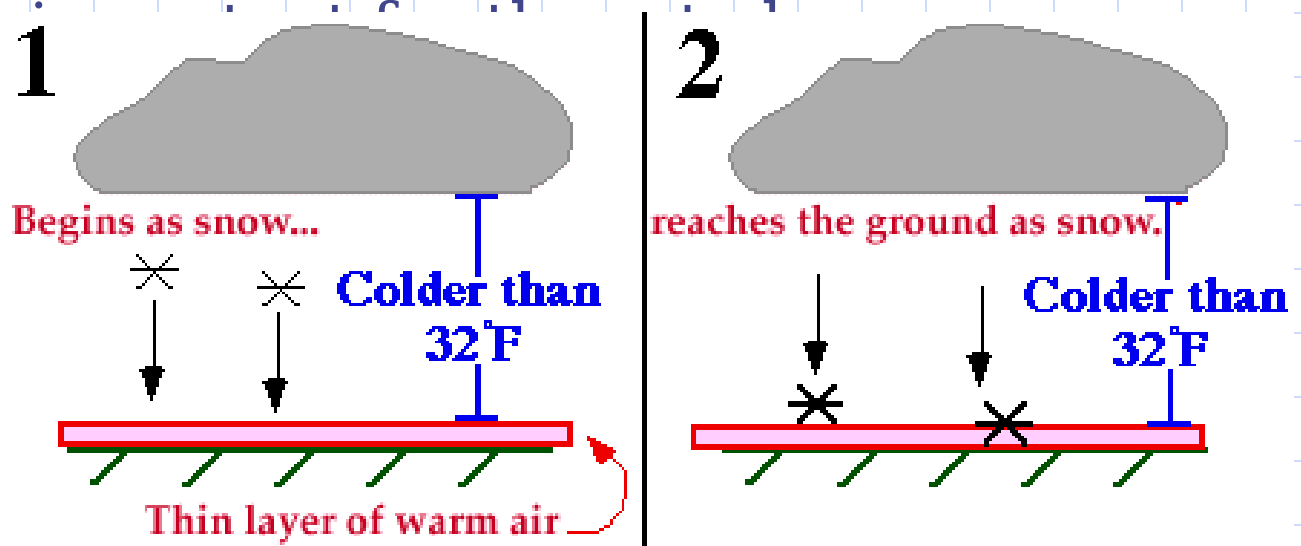
Most precipitation that reaches the ground actually begins as snow high in the atmosphere. These snow flakes develop somewhere above the freezing level where the air temperature is less than 32 F (the dashed blue line), and begin to fall toward the earth as snow. If ground temperature is above 32 F, the freezing level must be located somewhere above the ground. The falling snow passes through the freezing level and changes to rain before reaching the ground.



When the air temperature at the ground is less than 32 F, the precipitation begins falling as snow from



Since it is falling into cold air, the snow does not melt on the way down and reaches the ground as snow. This is why cold air is



Once in a while, a very thin layer of warm air is found near the surface and temperatures may be several degrees above freezing. However, since the layer of warm air is so shallow, the snow reaches the ground in tact before it has a chance to melt and become rain. This is how snow falls when the surface temperatures are above freezing.

Forecast tip! When forecasting precipitation type, if temperatures are expected to be above freezing, then rain is most likely. If temperatures are expected to be below freezing, then forecast for snow.